



**CITY OF
TUCSON**

Adopted by Mayor and Council
March 17, 2003

**Transportation
Access Management
Guidelines for the
City of Tucson,
Arizona**

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1.0 Introduction

In response to the need for more consistent and effective access management policies within metropolitan areas, various information has been compiled from many sources in the preparation of Access Management Guidelines for the City of Tucson. These guidelines define the overall concept of access management, review current practice, and set forth basic policy, planning, and design guidelines. The concepts presented are consistent with guidelines established by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), and the Institute of Transportation Engineers (ITE). For purposes of this report, “access” means the direct physical connection of adjoining land to a roadway via a street or driveway, including median openings. These guidelines will be adopted as ordinance and will become applicable to all new public and private developments.

2.0 Principles of Access Management

Constantly growing traffic congestion, concerns over traffic safety, and the ever increasing cost of upgrading roads have generated interest in managing the access to not only the roadway system, but to surface streets as well. Access management is the process that provides access to land development while simultaneously preserving the flow of traffic on the surrounding road system in terms of safety, capacity, and speed. Access management attempts to balance the need to provide good mobility for through traffic with the requirements for reasonable access to adjacent land uses.

The most important concept in understanding the need for access management is that through movement of traffic and direct access to property are in mutual conflict. No facility can move traffic effectively and provide unlimited access at the same time. The extreme examples of this concept are the freeway and the cul-de-sac: The freeway moves traffic very well with few opportunities for access, while the cul-de-sac has unlimited opportunities for access, but doesn’t move traffic very well. In many cases, accidents and congestion are the result of street operations attempting to serve both mobility and access at the same time. Figure 2-1 shows the relationship between mobility, access, and the functional classification of streets.

An effective access management program will accomplish the following:

- 1) ***Limit the number of conflict points at driveway locations.*** Conflict points are indicators of the potential for accidents. The more conflict points that occur at an intersection, the higher the potential for vehicular crashes. When left turns and cross street through movements are restricted, the number of conflict points are significantly reduced.

- 2) ***Separate conflict areas.*** Intersections created by streets and driveways represent basic conflict areas. Adequate spacing between intersections allows drivers to react to one intersection at a time, and reduces the potential for conflicts.
- 3) ***Reduce the interference of through traffic.*** Through traffic often needs to slow down for vehicles exiting, entering, or turning across the roadway. Providing turning lanes, designing driveways with large turning radii, and restricting turning movements in and out of driveways allows turning traffic to get out of the way of through traffic.
- 4) ***Provide sufficient spacing for at-grade, signalized intersections.*** Good spacing of signalized intersections reduces conflict areas and increases the potential for smooth traffic progression.
- 5) ***Provide adequate on-site circulation and storage.*** The design of good internal vehicle circulation in parking areas and on local streets reduces the number of driveways that businesses need for access to the major roadway.

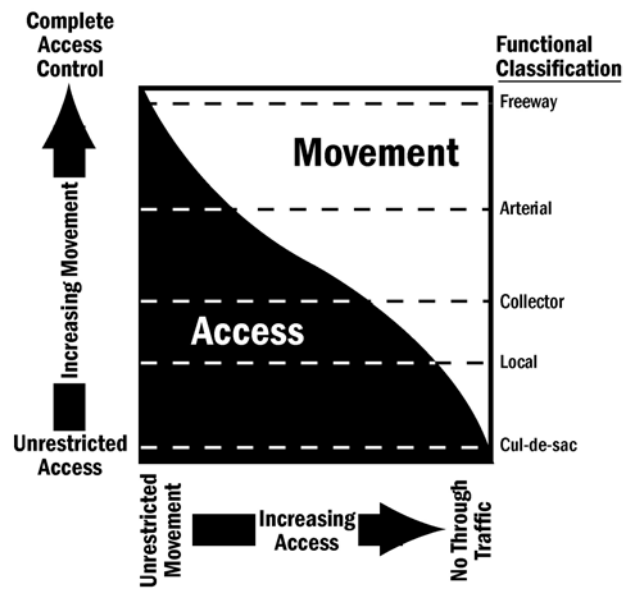
The typical “vicious cycle” of traffic congestion found in many areas of the country is shown in Figure 2-2. Access management attempts to put an end to the seemingly endless cycle of road improvements followed by increased access, increased congestion, and the need for more road improvements.

Poor planning and inadequate control of access can quickly lead to an unnecessarily high number of direct accesses along roadways. The movements that occur on and off roadways at driveway locations, when those driveways are too closely spaced, can make it very difficult for through traffic to flow smoothly at desired speeds and levels of safety. The American Association of State Highways and Transportation Officials (AASHTO) states that “the number of accidents is disproportionally higher at driveways than at other intersections...thus their design and location merits special consideration.” Additionally, recent research documented in the *5th Edition ITE Traffic Engineering Handbook* confirms a direct relationship between crash frequency and driveway frequency, driveway activity, and median access.

Fewer direct access points, greater separation of driveways, and better driveway design and location are the basic elements of access management. When these techniques are implemented uniformly and comprehensively, there is less occasion for through traffic to brake and change lanes in order to avoid turning traffic.

Consequently, with good access management, the flow of traffic will be smoother and average travel times lower. There will definitely be less potential for accidents. According to the Federal Highway Administration (FHWA), before and after analyses show that routes with well managed access can experience 50% fewer accidents than comparable facilities with no access controls.

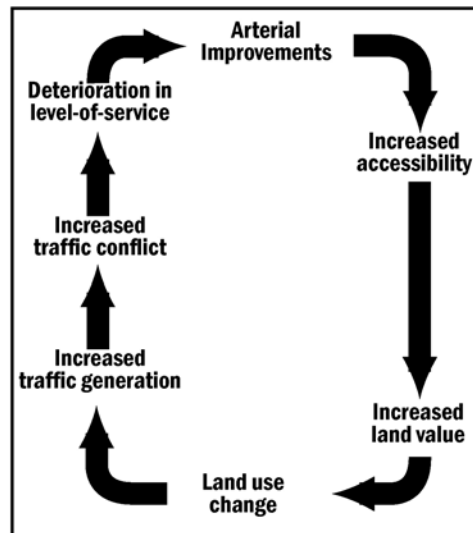
Movement vs. Access



Adapted from: NCHRP Report 348 "Access Management Policies and Guidelines for Activity Centers" Metro Trans Group, TRB Washington DC, 1992.

Figure 2-1

Cycle of Traffic Congestion



Adapted from: Vergil G. Stover and Frank J. Koepke, Transportation and Land Development, Institute of Transportation Engineers, 1988.

Figure 2-2

3.0 Roadway Functional Classification

3.1 Concepts

Access and mobility are competing functions. This recognition is fundamental to the design of roadway systems that preserve public investments, contribute to traffic safety, reduce fuel consumption and vehicle emissions, and do not become functionally obsolete. Suitable functional design of the roadway system also preserves the private investment in residential and commercial development.

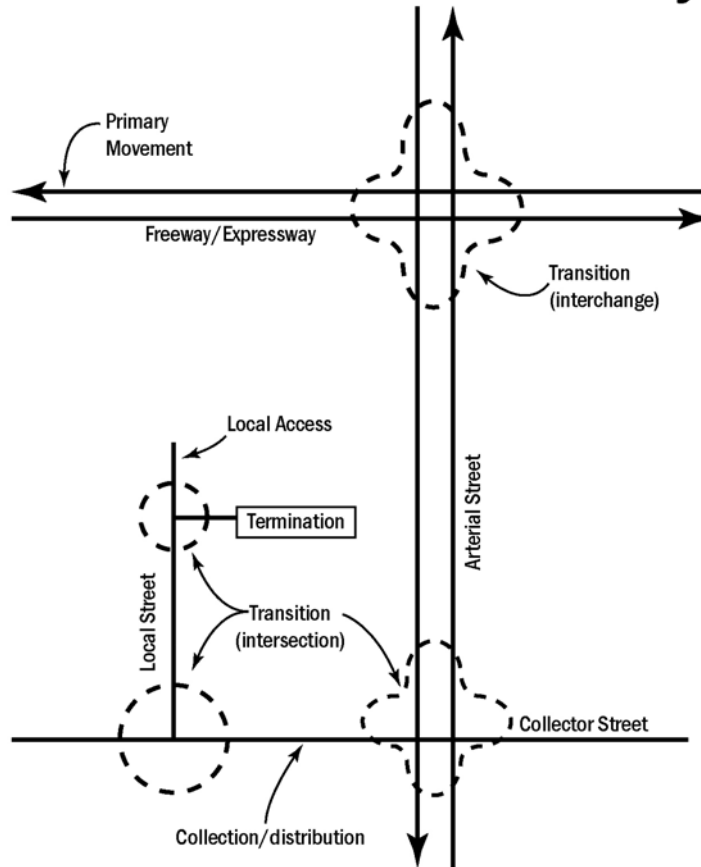
The *2001 AASHTO Policy on Geometric Design of Highways and Streets* (“Green Book”) recognizes that a functionally designed circulation system provides for distinct travel stages. It also indicates that each stage should be handled by a separate facility and that “the failure to recognize and accommodate by suitable design each of the different stages of the movement hierarchy is a prominent cause of roadway obsolescence.” The AASHTO policy also indicates that the same principles of design should be applied to access drives and comparable street intersections.

A typical trip on an urban street system can be described as occurring in identifiable steps or stages as illustrated in Figure 3-1. These stages can be sorted into a definite hierarchy with respect to how the competing functions of mobility and access are satisfied. At the low end of the hierarchy are roadway facilities that provide good access to abutting properties, but provide limited opportunity for through movement. Vehicles entering or exiting a roadway typically perform the ingress or egress maneuver at a very low speed, momentarily blocking through traffic and impeding the movement of traffic on the roadway. At the high end of the hierarchy are facilities that provide good mobility by limiting and controlling access to the roadway, thereby reducing conflicts that slow the flow of through traffic.

A transition occurs each time that a vehicle passes from one roadway to another and should be accommodated by a facility specifically designed to handle the movement. Even the area of transition between a driveway and a local street should be considered as an intersection and be treated accordingly. However, design of these intersections pose few problems since speeds and volumes are low. Many urban circulation systems use the entire range of facilities in the order presented here, but it is not always necessary or desirable that they do so.

The functional classification system divides streets into three basic types identified as arterials, collectors, and local streets. The function of an arterial is to provide for mobility of through traffic. Access to an arterial is controlled to reduce interference and facilitate through movement. Collector streets provide a mix for the functions of mobility and access, and therefore accomplish neither well. The predominate purpose of local streets is to provide direct access to adjoining property.

Hierarchy of Movement in a Functional Circulation System



Adapted from: A Policy on Geometric Design of Highways and Streets, Chapter 1, Washington DC, AASHTO, 2001.

Figure 3-1

Each class of roadway has its own geometric, traffic control, and spacing requirements. The general types of facilities and their characteristics are summarized in Table 3-1. This table provides a broad guide in setting access spacing standards that are keyed to functional classes of roadways.

TABLE 3-1
Functional Route Classification

Characteristic	Functional Classification		
	Arterial	Collector	Local
Function ¹	traffic movement, land access	traffic movement, land access, collect & distribute traffic between streets and arterials	land access
Continuity	continuous	not necessarily continuous	none
Spacing	1-2 miles	½ mile or less	as needed
Typical % of Surface Street System Travel Volume Carried ²	65-80%	5-20%	10-30%
Direct Land Access ²	<u>limited</u> : major generators only	<u>restricted</u> : some movements prohibited; number and spacing of driveways controlled	safety controls only
Speed Limit ¹	35-55 mph in fully developed areas	30-40 mph	25 mph
Parking ¹	prohibited	prohibited	Permitted
Bicycle Space in Lane Width	Yes	Yes	No

¹ Source: Transportation Research Board, (2000)

² Source: Institute of Transportation Engineers (ITE), (1999)

4.0 Access Spacing

Access spacing guidelines should be keyed to allowable access levels, roadway speeds, and operating environments. They should apply to new land developments and to significant changes in the size and nature of existing developments. They do not have to be consistent with existing practices. Because of historical conditions, access to land parcels that do not conform to the spacing criteria may be necessary when no alternative reasonable access is provided; however, the basis for these variances should be clearly indicated and approved by the City's Representative.

4.1 Signalized Intersections

In order to insure efficient traffic flow and safety, signalized intersections should be limited to locations along the city arterial and collector streets, where the progressive movement of traffic will not be significantly impeded. Uniform, or near uniform, spacing of traffic signals is critical for the progression of traffic in all directions. The spacing of traffic signals is fixed by the design of the city's street system and results in the mathematical ability to progress traffic signal operations. Failure to gain proper spacing will result in severe degradation to the system's operation. The spacing between traffic signals, pedestrian crossing needs, and the use of left-turn arrows, dictate two critical factors for good progression – traffic signal cycle length and resulting vehicle speed.

The optimum spacings are detailed in Table 4-1. In the Tucson street system, the traffic signal spacing is fixed or given at ½ mile increments (2640 feet). This spacing results in an operating speed of 40 miles per hour (mph) and a 90-second cycle to properly serve pedestrians and left-turn arrows. If the desire is to allow 45 mph speeds, the cycle length should be lowered to 80 seconds, thus reducing or eliminating the green time for pedestrians and left-turn arrows. If additional green time is desired for pedestrians and left-turn arrows, the only option remaining is a 120-second cycle length, however, the driver must only travel at approximately 30 mph. This lower speed is often unacceptable to drivers and can lead to disregard of speed limits and rushing from red light to red light.

As a guideline, traffic signal cycle lengths should be kept as short as possible and cycle lengths of 150 seconds or more should be avoided. Excessively long cycle lengths result in long vehicle queues, unreasonable delays, and potential air quality problems. Special protected turn only operations should be avoided.

The Mayor and Council may approve deviations in the spacing of signals as conditions change.

If non-standard traffic signal spacing is under consideration by the Mayor and Council, the following actions should be taken to mitigate the associated problems:

- 1) The group proposing the installation or retention of the traffic signal shall pay for its installation, operation and maintenance.
- 2) The group shall indemnify and insure the City and its personnel against any legal action as a result of the installation of the traffic signal at an unwarranted or improperly spaced location.
- 3) When side street traffic is present, the traffic signal should be actuated only every other cycle so that mainline traffic is interrupted half of the time between the hours of 6am and 11pm, Monday through Friday, if possible.
- 4) The actual or proposed traffic levels shall meet 1.5 times the volume requirements given in the latest edition of the MUTCD for traffic signal warrants. Warrants other than eight-hour volume warrants and accident warrants should be carefully evaluated before being accepted.
- 5) In order to mitigate negative effects of non-standard signal spacing, PELICAN or Florida “T” intersections/operations should be installed if possible.
- 6) These non-standard spaced traffic signals should be designed to operate in a two-phase mode. Additional phases and protected left-turn arrow movements are to be avoided whenever possible.

TABLE 4-1¹
Optimum Spacing of Signalized Intersections

Cycle Length (sec)	Operating Speed (mph)					
	30	35	40	45	50	55
	Distance in feet					
60	1320	1540	1760	1980	2200	2430
70	1540	1800	2050	2310	2560	2830
80	1760	2050	2350	2640	2930	3230
90	1980	2310	2640	2970	3300	3630
100	2200	2570	2930	3300	3670	4030
110	2420	2830	3220	3630	4040	4430
120	2640	3080	3520	3960	4400	4840
150*	3300	3850	4400	4950	5500	6050

* = Represents maximum cycle length for actuated signal if all phases are fully used.
This cycle length or greater cycle lengths should be avoided.

4.2 Unsignalized Intersections

Unsignalized intersections are far more common than signalized intersections. They affect all kinds of activity, not merely large activity centers. From a spacing perspective, driveways should be treated the same as unsignalized street intersections. Traffic operational

¹ Source: Transportation Research Board, (1992)

factors leading toward wider spacing of driveways (especially medium- and higher-volume driveways) include weaving and merging distances, stopping sight distance, acceleration rates, and storage distance for back-to-back left turns.

Strict application of traffic engineering criteria may push spacing requirements to 500 feet or more, however, such spacing may be unacceptable for economic development in many suburban and urban environments, where development pressures opt for 100- to 200-foot spacing.

Unsignalized intersection spacing standards should be used to determine the minimum acceptable distance between driveways and public streets. These minimum acceptable standards will also be affected by the surrounding land uses. It is necessary to consider adjacent land use in computing the generator size, including development across the street. It is not good practice to look at generators in isolation.

The standards should apply to both private driveways and unsignalized public streets where there is little likelihood for future signalization. Where signalization is imminent or likely, the signal spacing guidelines should govern activity.

There should be no direct residential lot access to arterials. Direct residential lot access to collectors should be minimized and avoided in new roadway development.

The spacing of right-turn only access points on each side of a divided roadway can be treated separately. However, where left turns at median breaks are involved, the access on both sides should line up or be offset from the median break by at least 300 feet.

Driveways adjacent to major signalized intersections, should be located a minimum of 300 feet from the intersection.

On undivided roadways, access on both sides of the road should be aligned. Where this is not possible, driveways should be offset by at least 150 feet minimum when two minor traffic generators are involved, and 300 feet minimum when two major traffic generators are involved.

4.3 Median Openings

Median openings are provided at all signalized at-grade intersections. They are also generally provided at unsignalized junctions of arterial and collector streets. They may be provided at driveways only where they will have minimum impact on roadway flow.

Minimum desired spacing of unsignalized median openings at driveways as functions of speed are given in Table 4-2. These spacings best apply to retrofit situations. Ideally, spacing of breaks should be conducive to signalization. Median openings for left-turn entrances (where there is no left-turn exit from the activity center) should be spaced to allow sufficient storage for left-turning vehicles.

TABLE 4-2¹
Minimum Spacing Between Unsignalized Median Openings

Speed Limit(mph)	Minimum Spacing (feet)
30	370
35	460
40	530
45	670
50	780
55	910

Guidelines for the spacing of median openings as functions of street classification are given in Table 4-3. This spacing should reflect traffic signal coordination requirements, storage space needed for left turns, bay tapers, and roadway aesthetic and landscaping goals.

TABLE 4-3²
Guidelines for Spacing Median Openings

Street Functional Classification	Spacing of Median Openings (in feet)		
	Urban	Suburban	Rural
Arterial	660	660	1320
Collector	330	660	1320

Median openings at driveways can be subject to closure where volumes warrant signals, but signal spacing would be inappropriate. Median openings should be set far enough back from nearby intersections to avoid possible interference with intersection queues. In all cases, storage for left turns should be adequate.

¹ Source: Koepke, Frank J., and Stover, Vergil G., (1988)

² Adapted from: Koepke, Frank J., and Stover, Vergil G., (1988)

Moreover, all median spacing guidelines are to be considered minimums and are not automatic. In determining if a median break request should be approved, the following issues should be considered:

- 1) The proposed median break is necessary for adequate access to an abutting property and must improve access and circulation without increasing accidents or accident rates.
- 2) The proposed median break will not cause a significant problem elsewhere (e.g. increased traffic in neighborhoods, increased accidents in another location, etc.)
- 3) If requested for development access, full consideration should be given to adjacent and opposite properties. Median break locations for individual developments should be coordinated with other affected property owners.
- 4) The location and design of any proposed median break meets acceptable engineering design standards for expected traffic speeds and volumes.
- 5) The proposed median break will not interfere with the continuity of traffic flow at or between intersections.
- 6) Before approving any median break request, the City may require a traffic engineering analysis by a professional traffic engineer. Such an analysis should address the issues stated in 1 through 5, and should be at the sole expense of the requestor.
- 7) The proposed median break will not be at a location where driveways on opposite sides of the roadway do not align.
- 8) Emergency vehicle access should be reviewed to provide adequate police and fire vehicle entry.
- 9) The group proposing the median opening is responsible to pay for the design and construction of improvements.
- 10) The City may require cross-access for adjacent developments/properties if a median opening request is granted.

4.4 Arterial Grade Separations

Interchanges and grade-separated intersections provide several important access management functions. They enable the signal green time to be maximized along expressways and arterials. They also allow access to large activity centers where such access might be precluded by traffic signal spacing criteria.

More specifically, a grade-separated intersection may be appropriate in the following situations:

- 1) Where two expressways cross, or where an expressway crosses arterial roads;
- 2) Where arterials cross and the resulting available green time for any route would be significantly decreased because of high demands for left turn arrow green time;
- 3) Where an existing at-grade signalized intersection along an arterial roadway operates at level of service (LOS) F, and there is no reasonable improvement that can be made to provide sufficient capacity;

- 4) Where a history of accidents indicates a significant reduction in accidents can be realized by constructing a grade separation;
- 5) Where a new at-grade signalized intersection would result in LOS E in urban and suburban settings and LOS D in rural settings;
- 6) When the location to be signalized does not meet the signal spacing criteria and signalization of the access point would impact the progressive flow along the roadway, and there is no other reasonable access to a major activity center;
- 7) Where a major public street at-grade intersection is located near a major traffic generator, and effective signal progression for both the through and generated traffic cannot be provided; and
- 8) The activity center is located along an arterial, where either direct access or left turns would be prohibited by the access code, or would otherwise be undesirable.

4.5 Guidelines for Consideration of Pedestrian and Bicycle Crossing Devices

The guidelines for evaluating location for the installation of various types of pedestrian and bicycle traffic control devices are set forth in the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) and the Traffic Control Device Handbook, published by the Federal Highway Administration. These guidelines are intended to assist the developer with evaluation of crosswalk location and determination of whether to consider installing the following types of devices. Final approval of all devices and locations will be by the City of Tucson Department of Transportation.

4.5.1 Marked Crosswalks

The developer shall use the Arizona Department of Transportation policy PGP-3B-3, February 1998 as a guide to decide whether or not to mark a crosswalk. The policy acknowledges that legally defined crosswalks exist at the intersection of all streets and highways. Locations considered for the installation of a painted crosswalk should meet the following criteria:

- 1) Meet the State of Arizona warrant for the consideration of a marked crosswalk, and
- 2) Recognize the use of a painted median lane as a safe haven for crossing pedestrians, except for school crossings, and
- 3) Placed at locations with adequate sight distance, and
- 4) No other marked crosswalk or STOP sign or traffic signal within 600 feet, and
- 5) The installation can be expected to reduce total accidents and not result in a greater number of rear-end and associated collisions due to pedestrians not waiting for adequate gaps in traffic.

4.5.2 School Crosswalks

The developer shall follow the Arizona Revised Statutes 28-797, the State of Arizona, “School Safety Program Guidelines” with additions by the Mayor and Council in Mayor and Council Policy 950-02.1, .2, .3.

4.5.3 HAWK – High Intensity Activated CrossWalk

Locations considered for the installation of marked crosswalks with pedestrian actuated beacon signal lights and signage should generally meet the following criteria:

- 1) Meet the Arizona State warrant for consideration of marked crosswalk, and
- 2) Meet the FHWA Traffic Control Devices Handbook guidelines for beacons at school crossings, i.e. Pedestrian volume of 40 to 60 pedestrians crossing during a 2-hour period of a normal day; Where the 85th percentile vehicle speed is in excess of 35 mph (Note: Vehicle speed refers to the speed of vehicles approaching the beacon), and
- 3) There is no other crossing controlled by a traffic signal, stop sign or crossing guard within 600 feet of the proposed location, and
- 4) If a school crossing, the intersection is identified on the “School Route Plan” and/or has a significant number of special needs pedestrians

4.5.4 TOCAN – Two GrOups CAN Cross

(Bicycle/Pedestrian Crossing - This crossing is designed specifically to facilitate bicycle access.)

Locations considered for the installation of this combination of devices should generally meet the following criteria:

- 1) Meet the State of Arizona warrant for the consideration of a marked crosswalk, and
- 2) Meet an MUTCD warrant for consideration of a traffic signal installation: Warrant 1 – Eight-Hour Vehicular Volume, Warrant 2 – Four-Hour Vehicular Volume, Warrant 3 – Peak-Hour, Warrant 4 – Pedestrian Crossing, or Warrant 5 – School Crossing, and
- 3) Installation is in conformance with the Tucson Roadway Development Policy Ordinance, and
- 4) Ability to install barrier islands to prohibit all motor vehicle traffic crossing the street and only right turns are permitted

4.5.5 PELICAN – PEdestrian LIght ACtuAtioN

Locations considered for the installation of this combination of devices should generally meet the following criteria:

- 1) Meet the State of Arizona warrant for the consideration of a marked crosswalk, and

- 2) Meet an MUTCD warrant for consideration of a traffic signal installation: Warrant 4 – Pedestrian Crossing or Warrant 5 – School Crossing, and
- 3) Spacing is not in violation of the Tucson Roadway Development Policy Ordinance, and
- 4) If designed as a school crossing the location is on the “School Route Plan”, and
- 5) The proposed location is not within 600 feet of another signalized crossing or STOP sign or flashing beacon and sign crossing.

5.0 Design Standards

5.1 Street Cross Sections

(Refer to Tucson Major Streets & Routes for specific cross sections of Roadways)

Cross sections are the combination of the individual design elements that typify the design of the roadway. Cross section elements include the pavement surface for driving and parking lanes, curb and gutter, bike lanes, alternate mode facilities, sidewalks and additional buffer/landscape areas. Right-of-way is the total land area needed to provide for all of the cross section elements.

The design of the individual roadway elements depends upon the facility’s intended use. Roads with higher design volumes and speeds require more travel lanes and wider right-of-way than low volume, low speed roads. Furthermore, the high-use roadway type should include wider shoulders and medians, separate turn lanes, dedicated bicycle lanes, elimination of on-street parking and control of driveway access. For most roadways, an additional buffer area is provided beyond the curb line. This buffer area accommodates the sidewalk area, landscaping, and local utilities. Locating the utilities outside the traveled way can minimize traffic disruption if utility repairs or service changes are required.

Typical elements of the roadway cross sections are identified in the following sections. However, few of the dimensions used in street design have been precisely determined by research. Instead, the cross sections usually represent a consensus of opinion based upon engineering judgment and operating experience. Therefore, each of the elements of roadway design can be altered to better accommodate various conditions found in Tucson.

5.1.1 Local Streets Local streets provide direct access to abutting land uses and accommodate local traffic movement. Local streets should be designed to provide slow speeds and relatively low traffic volumes. On-street parking is usually permitted and bicycles can be accommodated without a separate travel lane.

5.1.2 Collectors Collector streets provide for traffic movement between local streets and arterial streets. Collector streets also provide access to abutting land uses. There is no parking allowed on collector streets. Adequate bicycling space is provided in each 17-foot travel lane. On major bicycle routes, this lane is to be striped as a 5-foot bicycle lane with a travel lane.

Individual driveway openings onto collectors should be designed to eliminate backing movements onto the street.

5.1.3 Arterials Arterial streets provide for major through traffic movement between geographic areas. These roadways typically have some form of access control that limits the locations of driveways.

The maximum width of an arterial street should be no more than six lanes in the midblock, except where the additional lanes are designated for buses, bicycles, and high-occupancy vehicles. Where traffic volumes create the need for additional capacity, intersection modifications should be pursued prior to further widening. A curbed median of no less than 20-feet should be included in the design of all arterial streets where the curb to curb width exceeds 75-feet.

Due to potential conflicts with through traffic, there are no lanes allowed for on-street parking. On-street bus stops may interfere with through traffic and bus turnouts may be needed for this design. Any needed right-turn lanes can also be provided with roadway widening into the buffer area. Additional buffer beyond the curb line should be provided on principal arterial streets for turnouts and future widening.

5.2 Sight Distance

It is essential to provide sufficient sight distance for vehicles using a driveway. They should be able to enter and leave the property safely with respect to vehicles in the driveway and vehicles on the intersecting roadway. See the City of Tucson Development Standards for Sight Visibility Triangle Requirements.

5.3 Turning Lanes

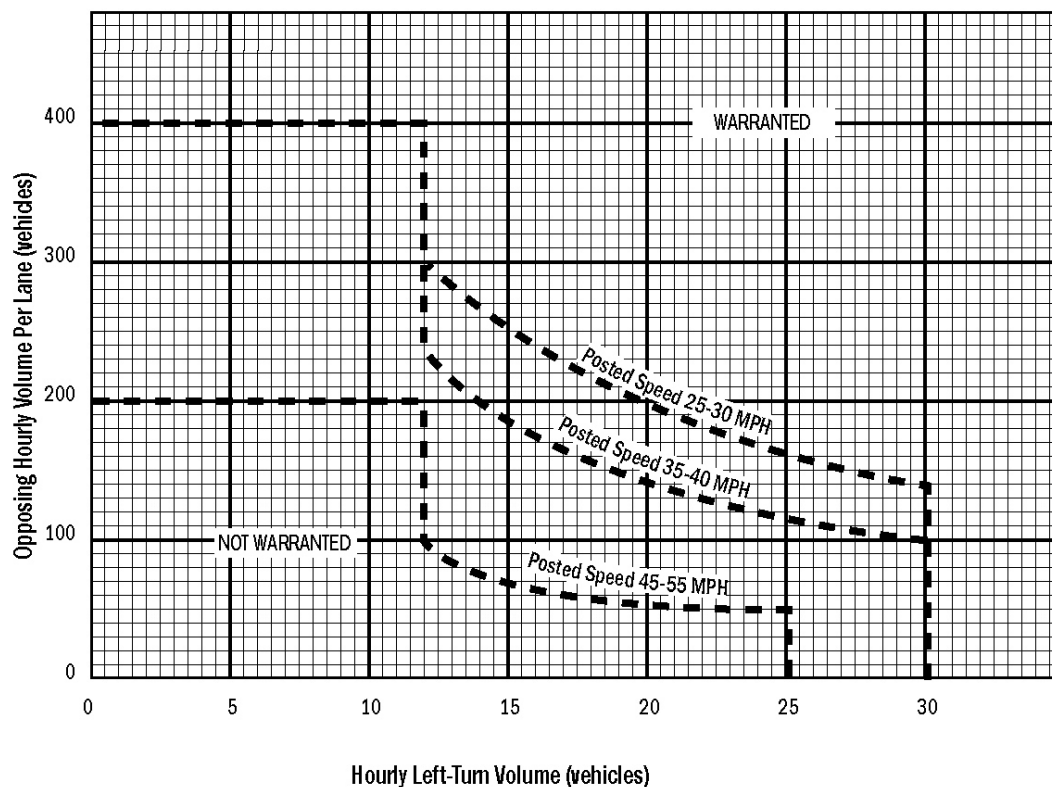
5.3.1 Need It may be necessary to construct turning lanes for right and left turns into an access drive for safety or capacity reasons where roadway speeds or traffic volumes are high, or if there are substantial turning volumes. The purpose of a separate turning lane is to expedite the movement of through traffic, increase

intersection capacity, permit the controlled movement of turning traffic, and promote the safety of all traffic.

The provision of left-turn lanes is essential from both capacity and safety standpoints where left turns would otherwise share the use of a through lane. Shared use of a through lane will dramatically reduce capacity, especially when opposing traffic is heavy. One left turn per signal cycle delays 40 percent of the through vehicles in the shared lane; two turns per cycle delays 60 percent.¹

Right-turn lanes remove the speed differences in the main travel lanes, thereby reducing the frequency and severity of rear-end collisions. They also increase capacity of signalized intersections and may allow more efficient traffic signal phasing. Figures 5-1 and 5-2 illustrate typical warrants for left- and right-turn lanes, based on posted speed and traffic volumes.

Left-Turn Lane Warrant

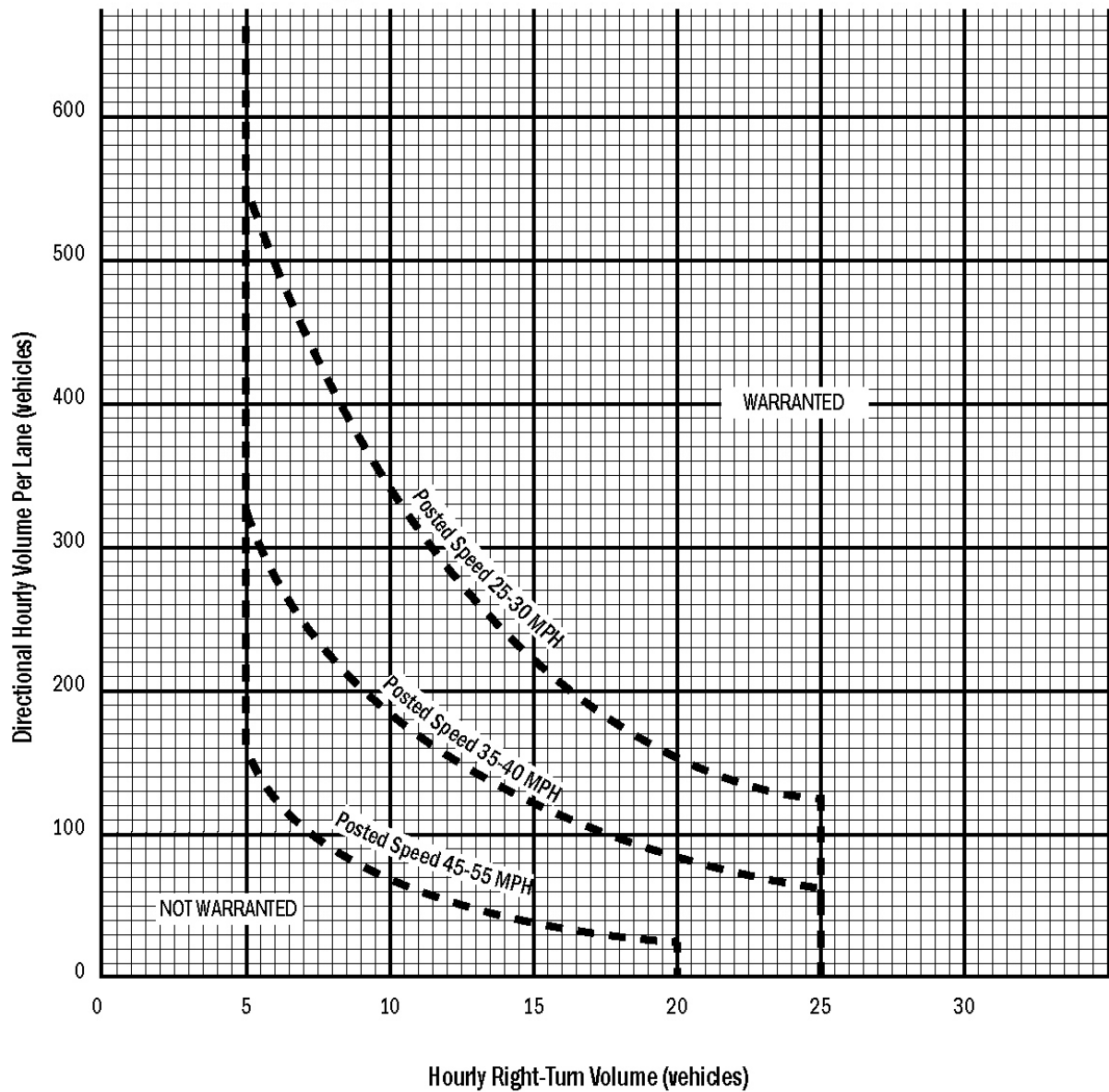


Sources: Idaho Transportation Department "Traffic Manual";
Transportation Research Board, NCHRP Report 348, *Access Management Guidelines for Activity Centers*.

Figure 5-1

¹ Source: Transportation Research Board, (1989)

Right-Turn Lane Warrant



Sources: Idaho Transportation Department "Traffic Manual";
Transportation Research Board, NCHRP Report 348, Access Management Guidelines for Activity Centers.

Figure 5-2

Rear-end accidents can be severe on shared lanes. Research has found that accident rates increase exponentially as the speed differential in the traffic stream increases.¹ While the accident rates may change over time and by location, the ratio of the accident rates is expected to provide a good indication of the relative accident potential at different speed differentials, as shown in Table 5-1. As shown, on an arterial street, a vehicle traveling 35 mph slower than other traffic is 180 times more likely to become involved in an accident than a vehicle traveling at the same speed as other traffic.

TABLE 5-1¹
Relative Accident Involvement Rates

Speed Differential (mph)	Relative Accident Potential as Compared to:	
	At-Grade Arterials	Freeways
	0-mph Differential	0-mph Differential
0	1	1
-10	2	3.3
-20	6.5	20
-30	45	67
-35	180	N/A

N/A = not available

Vehicular lanes for right turn movements and/or acceleration may be required adjacent to driveways on streets having a posted speed limit of 35 mph or greater or where the Average Daily Traffic (ADT) of the driveway exceeds 1,000 vehicles/day. Left turn lanes, with appropriate transitions, may be required on streets that exist at less than full future width or where significant turning movements will occur. The minimum turn lane width is 12-feet unless approved by the Director of Transportation or designated staff.

The Tucson Department of Transportation will determine when right turn and/or left-turn lanes are required, based on a traffic analysis supplied by the developer. The analysis must comply with the procedures detailed in the Highway Capacity Manual, latest edition, or with procedures supplied by the Tucson Department of Transportation.

5.3.2 Total Length A separate turning lane consists of a taper plus a full width auxiliary lane. The design of turn lanes is based primarily on the speed at which drivers will turn into the lane, the speed to which drivers must reduce in order to turn into the driveway after traversing the lane, and the amount of vehicular storage that

¹ Source: Institute of Transportation Engineers, (1988)

should be required. Other special considerations include the volume of trucks that will use the turning lane and the steepness of an ascending or descending grade.

Although vehicular storage is a principal factor used to establish the full length of a separate turn lane, it may not be the actual determining factor. At off-peak traffic periods on higher-speed roads, the lane will function as a right turn lane.

The distance required for storage length will vary, depending on traffic volumes, the type of traffic control, and traffic signal timing and phasing (if applicable). Required storage lengths should be calculated by traffic engineering analysis on a case-by-case basis.

The total length of the separate turning lane and taper should be determined by either:

- 1) Right turn lane requirements; or
- 2) The combination of turn lane or through lane queue storage plus the distance necessary to maneuver or transition into the separate lane, whichever is greater.

It is recommended that a minimum 10:1 bay taper be used to provide a full-width separate turning lane for all posted speed limits. If a two-lane turn lane is to be provided, it is recommended that a minimum 7.5:1 bay taper be used to develop the dual lanes. The bay taper will allow for additional storage during short duration surges in traffic volumes.

It is sometimes necessary to transition through traffic lanes around left-turn lanes. In such cases, larger transition rates should be used. The transition rate for through traffic should be approximately equal to the operating speed, but never less than half the operating speed (e.g., for a 40-mph operating speed and a 12-foot offset, the minimum taper would be 20:1 or 240 feet, and the desirable taper would be 40:1 or 480 feet).

5.3.2.1 Calculation of Total Length

A. Pavement Taper

Pavement tapers are to be designed based upon the following formulas. (From the *Manual on Uniform Traffic Control Devices [MUTCD]* 1988 or approved subsequent editions).

- 1) For a posted speed (d) less than or equal to forty mph, the length (L) of the taper in feet is:

$$L = \frac{([d]^2 \times \text{offset } \{\text{ft.}\})}{60}$$

- 2) For a posted speed (d) greater than forty mph, the length (L) of the taper in feet is:

$$L = ([d] \times \text{offset } \{\text{ft.}\})$$

B. Storage Length

The formulas contained in the 1973 AASHO Design Manual should be used to calculate the average queue storage length. The formulas differ slightly depending on the intersection traffic control.

- 1) Signalized Intersection with Protected Turn Phases

$$L_{\text{Queue}} = f * V * (C/3600) * [(C-g)/C] * I_{\text{veh}}$$

- 2) Signalized Intersection with Permissive Turn Phases

$$L_{\text{Queue}} = f * V * (C/3600) * I_{\text{veh}}$$

- 3) Unsignalized Intersection and Driveways With Stop Control

$$L_{\text{Queue}} = f * V * (120/3600) * I_{\text{veh}}$$

Where:

L_{Queue} = required storage length (feet)
 f = storage length factor, 1.25 to 2.0 (see below)
 V = hourly turning volume in vehicles per hour
 C = cycle length in seconds
 g = protected green time for turning movements in seconds
 I_{veh} = average vehicle length in feet (assume 20 feet)

Storage Length Factor:

f = 2.0, for $V < 300\text{vph}$
 f = 1.75, for $300 \leq V \leq 500\text{vph}$
 f = 1.5, for $500 \leq V \leq 1000\text{vph}$
 f = 1.25, for $V > 1000\text{vph}$

- 4) Minimum storage spacing at a signalized intersection is approximately 75 feet for a right-turn and 150 feet for a left-turn.
- 5) Minimum storage spacing at an unsignalized intersection is approximately 75 feet for both a right-turn and left-turn.

5.4 Driveway Locations

Design requirements for driveway locations onto arterial and collector roadways in all new development are as follows:

- 1) Entrance and exit drives crossing arterials and collectors are limited to two per three hundred feet of frontage along any major roadway. The nearest pavement edges spaced at least eighty feet apart.
- 2) A minimum of one hundred and fifty feet, measured at curblines, shall separate the nearest pavement edge of any entrance or exit driveway and the curblines to any signalized intersection with arterial and collector roadways.
- 3) All new development should promote cross access agreements to limit the number of driveways crossing arterial and collector roadways.

5.5 Driveway Curb Radius

The preferred curb radii will depend on the type of vehicles to be accommodated, the number of pedestrians crossing the access road, and the operating speed of the accessed roadway. Table 5-2 presents the minimum curb return radius for connection between two-types of streets, i.e. the minimum curb return for an arterial street to an arterial street is 30-feet.

TABLE 5-2¹
Minimum Curb Return Radius

	Arterial Street	Collector Street	Local Street	Driveway/PAAL
Arterial Street	30'	25'	25'	25'
Collector Street	25'	25'	25'	25'
Local Street	25'	25'	18'	18'
Driveway/PAAL	25'	25'	18'	18'

5.6 Driveway Entry Width

The entry width is the approximate width needed at the driveway throat to accommodate the swept path of the turning design vehicle. The return radii given in Table 5-2 represent the minimums developed from design vehicles turning into a driveway from the right-most lane. The entry width will differ from the driveway's overall width, depending on how the driveway is expected to operate. Driveway entries should be placed outside of erosion control, treated slopes, no access/access control or restricted utility easements.

All curb cuts, curb returns, and curb depressions should be located in accordance with the City of Tucson Code, Chapter 25 (see guidelines below in Table 5-3). The Director of Transportation or designated staff may grant written permission from the minimum and maximum guidelines shown below if the area has peculiar visible conditions, the nature of the business is exceptional, the nature of the abutting property is exceptional, and the variance is not against the public interest, safety, convenience or general welfare.

TABLE 5-3²
Driveway Entry Widths

	Residential Districts	Business Districts	Industrial Districts¹
Driveway width (min./max.)	10' / 20'	35' max	35' max
Max. driveway width for two adjoining properties	30'	n/a	n/a
Max. driveway width at the property line	n/a	30'	30'
Note: 1) The provisions established for curb cuts and driveways for business zoned district shall prevail in all industrial zoned districts for properties fronting on a through street, as defined in the City of Tucson Code, or on a major street as shown on the latest MS&R Plan on file with the Director of Transportation or designated staff.			

¹ Source: City of Tucson Development Standard No. 3-01.10 Figure 6, City of Tucson, Arizona, (1998)

² Source: Tucson Code, City of Tucson Adopted (1964) Enacted August 6, 2002

5.7 Driveway Profiles

The slope of a driveway can dramatically influence its operation. Usage by large vehicles can have a tremendous effect on operations if slopes are severe. The profile, or grade, of a driveway should be designed to provide a comfortable and safe transition for those using the facility, and to accommodate the storm water drainage system and reduce erosion or not impact erosion control, of the roadway.

Driveways should also be designed in compliance with ADA guidelines.

5.8 Driveway Throat Length¹

The driveway throat should be of sufficient length to enable the intersection at the access connection and abutting roadway, and the on-site circulation to function without interference with each other. Drivers entering the site should be able to clear the intersection of the roadway and access connection before encountering the intersection of the access connection and on-site circulation. Inadequate throat length results in poor access circulation in the vicinity of the access drive. This produces congestion and high crash rates on the abutting streets as well as on site. Pedestrian vehicular conflicts are also especially critical because of the confusion caused by the complex pattern of over-lapping conflict areas.

The exit side of an access connection should be designed to enable traffic leaving the site to do so efficiently. Stop-controlled connections should be of sufficient length to store three passenger cars (one passenger car = 20-feet).

5.9 Truck Loading Area

Truck loading areas should be designed in such a way as to minimize conflict with on-site traffic and circulation. Drop-off/loading areas should not be located where they will have an effect on vehicle operations on City right-of-way.

5.10 Median Openings

Left-turn ingress or egress requires a median opening when traffic traveling in opposing directions is separated by a barrier median. Median widths commonly vary from 4 feet to over 30 feet. Widths ranging from 14 to 20 feet are desirable for providing separate left-turn lanes.

Design elements include the median width, the spacing of median openings (see Section 4.3), and the geometrics of median noses at openings. The design of the median nose can vary from semicircular, usually for medians in the 4-foot to 10-foot range, to bullet nose design, for wider medians and for intersections that will accommodate semi-trailer trucks.

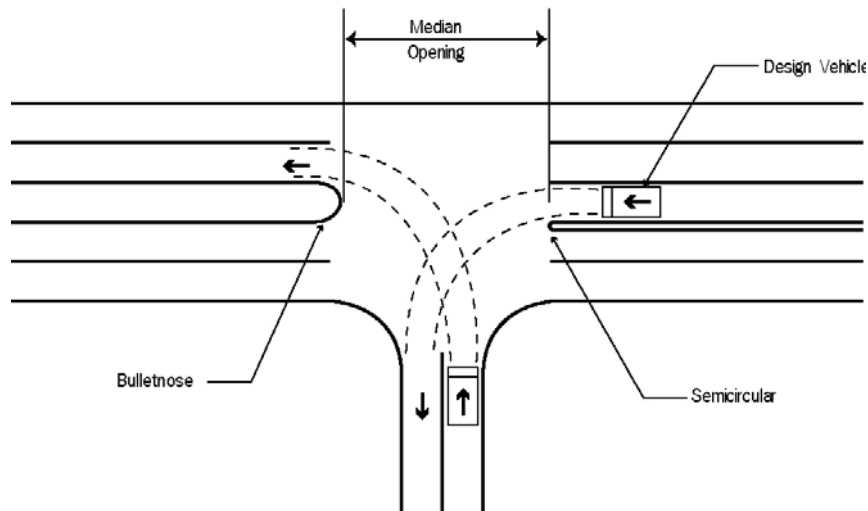
The bullet nose is formed by two symmetrical portions of control radius arcs that are terminated by a median nose radius that is normally one-fifth the width of the median (e.g., a

¹ Source: Federal Highway Administration. (1998)

bullet nose design for a median opening in a 20-foot-wide median would have a small nose radius of 4-feet that could connect two 50-foot radii).

The large radii should closely fit the path of the inner rear wheel of the selected design vehicle. The advantages are that the driver of the left-turning vehicle, especially a truck, has a better guide for the maneuver. The median opening can be kept to a minimum, and vehicle encroachment is minimized. Figure 5-3 indicates the various elements of a median opening design.

Minimum Median Openings



Median Openings Design Controls		
Control Radius (feet)	Design Vehicles Accommodated	
	Predominant	Occasional
40	P	SU
50	SU	WB-40
75	WB-40	WB-50

Median Width (feet)	Minimum Median Opening (feet)	
	Semicircular	Bullet Nose
12	88	58
18	82	47
20	80	44
30	70	40 minimum
40	60	40 minimum
50	50	40 minimum
60	40 minimum	40 minimum

Source: *A Policy on Geometric Design of Highways and Streets* - 4th Edition, American Association of State Highway & Transportation Officials, 2001.

Figure 5-3

5.11 Pedestrian Facilities¹

Pedestrian facility improvements on major roadway projects should utilize all applicable City of Tucson Department Standards, City of Tucson Specifications and Details, and Arizona Department of Transportation (ADOT) Standards, and should be compliant with the transportation and public accommodation provisions of the ADA.

All major roadway projects should include sidewalks on both sides of the improved roadway section. When adequate right-of-way is available, consideration should be given to providing sidewalks of greater width than minimum Development Standard Specifications. Consideration should be given to extending sidewalks to local and regional activity centers up to one-quarter mile beyond the project limit, in order to create a convenient, safe, and attractive pedestrian network. Consideration should be given to the utilization of alternative paving materials and designs, such as brick pavers and meandering sidewalks that enhance the overall aesthetic value of the project and complement existing urban design.

5.12 Bicycle Facilities¹

To promote the use of bicycles as an alternative mode of transportation, and to provide for bicyclist safety, major roadway projects should be designed with outside vehicle lanes that accommodate five-foot wide on-street bicycle routes with painted edgelines when adequate right-of-way is available.

Bicycle facility improvements on major roadway projects should utilize all appropriate AASHTO Design Guidelines, Arizona Bicycle Facility Design Guidelines, MUTCD, City of Tucson Development Standards, and the City of Tucson Specifications and Details.

All major roadway projects involving the reconstruction of intersections should provide for painted edgeline bicycle routes or additional outside vehicle lane width as part of the intersection improvement when adequate right-of-way is available. Actuated signal detection or video camera detection should be provided so that the bicyclist can actuate the traffic signal.

5.13 Transit Facilities²

In order to provide convenient access to public transit, bus stops should be placed every one-quarter mile on major roadway projects located along existing local transit routes, and every one-half mile to one mile along express or limited routes. Additional stops may be considered to serve major trip generators. Unless otherwise warranted by overriding safety concerns for passenger convenience issues, bus stops should be located on the far side of the intersections.

Bus shelters should be provided at all bus stops located along major roadway projects to provide for passenger comfort and safety.

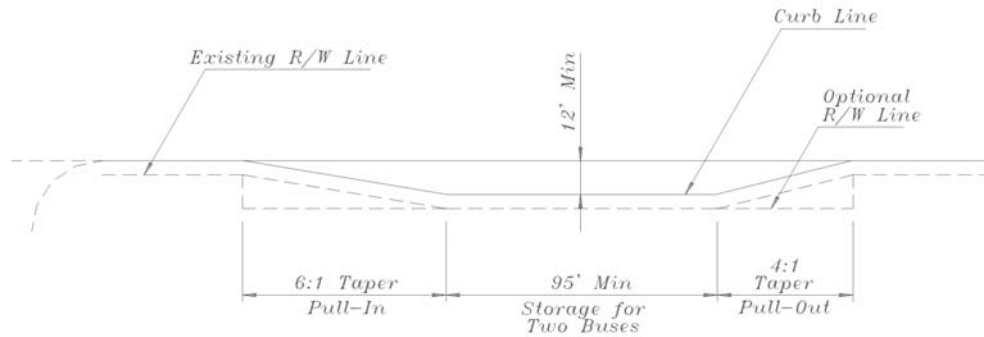
¹ Source: City of Tucson Department of Transportation. (1998)

² Source: City of Tucson Department of Transportation. (1998)

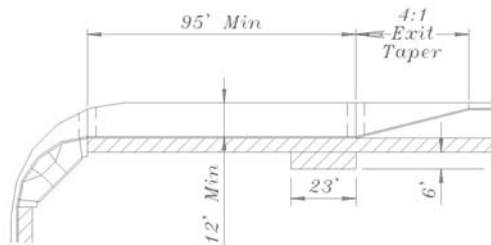
Major roadway projects should include bus pullouts at high activity bus stops when warranted by peak hour traffic, peak hour bus frequency, passenger safety concerns, and when adequate right-of-way is available. Bus pullouts should be located on the far side of intersections in order to utilize signal protection for re-entry into the stream of traffic. Consideration should be given to far-side open bus bays, coupled with a permitted through movement for buses in the right-turn lane at the intersection. This bus bay design enables transit vehicles to by-pass traffic queues at intersections thus assisting in on-time performance and providing additional passenger convenience. Bus pullouts should be carefully planned and designed to minimize transit vehicle delay in re-entering the stream of traffic. Bus pullouts should include shelters and other passenger amenities to provide for customer safety and convenience.

For the design of a bus bay, it is recommended that a minimum 6:1 bay taper be used to provide a twelve-foot minimum width bus bay. The bus bays should provide for 95-feet of storage length, unless it is a layover location, and if necessary a 4:1 exit taper. Figure 5-4 provides the bus bay details for two types of design.

Bus Bay Details



Detail #1 (Major Intersections)



DETAIL #2 (Minor Intersection)

a) Adapted From: Maricopa Association of Governments, Bus and Parking Detail No. 252, 2001
b) Adapted From: City of Glendale Transportation Department, Bus Bay Standard Detail No. G-406, 1991

Figure 5-4 Bus Bay Detail

6.0 Methods of Application

6.1 Traffic Impact Analysis

The City may request that a traffic impact Analysis (TIA) be prepared for proposed developments consistent with its policies. A detailed description of the methodology and necessary data is presented in Section 6.3.2.

6.2 Variances

Where the City of Tucson finds that extraordinary hardships or practical difficulties may result from strict compliance with approved requirements, the City may approve variations to the requirements, provided that safety standards are met, so that the public interest is served. The agency may require that a traffic impact analysis (TIA) or other information or studies be submitted when reviewing a request for a variation. Variances may be necessary for exceptions to turning restrictions or spacing standards where it can be demonstrated that no other reasonable options are available.

Economic development factors may be considered for development projects that will bring new job opportunities into the area. However, safety standards should not be compromised for purely economic reasons.

A petition for any variation should be submitted in writing to the City by the developer. The developer must prove that the variation will not be contrary to the public interest and that unavoidable practical difficulty or unnecessary hardship will result if not granted. The developer should establish and substantiate that the variation conforms to the City's requirements and standards.

Care should be taken in issuing variances. No variation should be granted unless it is found that the following relevant requirements and conditions are satisfied. The City may grant variations whenever it is determined that all of the following criteria have been met:

- 1) The granting of the variation should be in harmony with the general purpose and intent of the regulations and should not result in undue delay or congestion or be detrimental to the safety of the motoring public using the roadway.
- 2) There should be proof of unique or existing special circumstances or conditions where strict application of the provisions would deprive the developer of reasonable access. Circumstances that would allow reasonable access by a road or street other than a primary roadway, circumstances where indirect or restricted access can be obtained, or circumstances where engineering or construction solutions can be applied to mitigate the condition should not be considered unique or special.
- 3) There should be proof of the need for the access and a clear documentation of the practical difficulty or unnecessary hardship. It is not sufficient to show that greater profit or economic gain would result if the variation were granted. Furthermore, the hardship or difficulty cannot be self-created or self-imposed; nor

can it be established on this basis by the owner who purchases with or without knowledge of the applicable provisions. The difficulty or hardship must result from strict application of the provision, and it should be suffered directly and solely by the owner or developer of the property in question.

Upon receipt of relevant information, facts and necessary data, the governmental agency should review the information and render a decision in writing to the developer. Materials documenting the variance should be maintained in the agency's permit files.

6.3 Site Design

This sub-section sets forth criteria for access control and traffic impact analyses, as they apply to individual developments.

6.3.1 Access Control Typical access control requirements for arterials and collectors are provided as follows:

- 1) No driveway access to an arterial street should be allowed for any residential lot. Driveway access to collectors from residential lots should be discouraged and approved on a case-by-case evaluation.
- 2) No driveway access should be allowed within 300 feet of the nearest right-of-way line of an intersecting street.
- 3) Driveways giving direct access may be denied if alternate access is available.
- 4) When necessary for the safe and efficient movement of traffic, access points may be required to be designed for right turns in and out only.
- 5) When approved, or directed by the City's representative, a driveway access design may be a "street type intersection" with curb returns.

6.3.2 Traffic Impact Analysis A Traffic Impact Analysis (TIA) is a specialized study of the impacts that a certain type and size of development will have on the surrounding transportation system. A TIA is essential for many access management decisions, such as spacing of driveways, traffic control devices, and traffic safety issues. It is specifically concerned with the generation, distribution, and assignment of traffic to and from new development. A TIA should also be used as part of the site planning process, not merely justification of the site plan. The purpose of this sub-section is to establish uniform guidelines for when a TIA is required and how the study is to be conducted.

6.3.2.1 Requirements A complete TIA should be performed if any of the following situations are proposed:

- 1) All new developments, or additions to existing developments, which are expected to generate more than 100 new peak-hour vehicle trips

(total in and out vehicular movements). The peak-hour will be determined by the City's representative.

- 2) In some cases, a development that generates less than 100 new peak hour trips may require a TIA if it affects local "problem" areas. These would include high accident locations, currently congested areas, or areas of critical local concern. These cases will be based on the City representative's judgment.
- 3) All applications for rezoning or special exception (e.g. big box).
- 4) All applications for annexation.
- 5) Any change in the land use or density that will change the site traffic generation by more than 15 percent, where at least 100 new peak-hour trips are involved.
- 6) Any change in the land use that will cause the directional distribution of site traffic to change by more than 20 percent.
- 7) When the original TIA is more than 2 years old, access decisions are still outstanding, and changes in development have occurred in the site environs.
- 8) When development agreements are necessary to determine "fair share" contributions to major roadway improvements.

The specific analysis requirements, and level of detail, are determined by the following requirements.

- **CATEGORY I TIA** -- Developments which generate from 100 up to 500 peak hour trips. The study horizon should be limited to the opening year of the development. The minimum study area should include site access drives and adjacent signalized intersections and/or major unsignalized street intersections.
- **CATEGORY II TIA** -- Developments that generate from 500 up to 1,000-peak hour trips. The study horizon should include both the opening year of the development and five years after opening. The minimum study area should include the site access drives and all signalized intersections and/or major unsignalized street intersections within one-half mile of the development.
- **CATEGORY III TIA** -- Developments that generate 1,000 or more peak hour trips. The study horizon should include the opening year of the development, five years after opening and ten years after opening. The minimum study area should include the site access drives and all signalized intersections and/or major unsignalized street intersections within one mile of the development.

6.3.2.2 Qualifications for Preparing Traffic Impact Analysis Documents.

The TIA should be conducted and prepared under the direction of a Professional Traffic Engineer. The subject engineer should have special training and experience in traffic engineering.

6.3.2.3 Analysis Approach and Methods. The traffic study approach and methods should be guided by the following criteria.

6.3.2.3.1 STUDY AREA. The minimum study area should be determined by project type and size in accordance with the criteria previously outlined. The extent of the study area may be either enlarged, or decreased, depending on special conditions as determined by the City's representative.

6.3.2.3.2 STUDY HORIZON YEARS. The study horizon years should be determined by project type and size, in accordance with the criteria previously outlined.

6.3.2.3.3 ANALYSIS TIME PERIOD. Both the morning and afternoon weekday peak hours should be analyzed, unless the proposed project is expected to generate no trips, or a very low number of trips, during either the morning or evening peak periods. If this is the case, the requirement to analyze one or both of these periods may be waived by the City's representative.

Where the peak traffic hour in the study area occurs during a different time period than the normal morning or afternoon peak travel periods (for example mid-day), or occurs on a weekend, or if the proposed project has unusual peaking characteristics, these additional peak hours should also be analyzed.

6.3.2.3.4 SEASONAL ADJUSTMENTS. When directed by the City's representative, the traffic volumes for the analysis hours should be adjusted for the peak season, in cases where seasonal traffic data is available.

6.3.2.3.5 DATA COLLECTION REQUIREMENTS. All data should be collected in accordance with the latest edition of the ITE Manual of Traffic Engineering Studies, or as directed by the City of Tucson's Traffic Engineer.

6.3.2.3.5.1 Traffic volumes. Manual turning movement counts should be obtained for all existing cross-street intersections to be analyzed during the morning and afternoon peak periods. Turning movement counts may be required during other periods as directed by the City's representative.

6.3.2.3.5.2 Daily traffic volumes. The current and projected daily traffic volumes should be presented in the report. If available, daily count data from the City of Tucson, Pima County, or the Pima Association of Governments (PAG) may be used. Where daily count data is not available, mechanical counts will be required at locations agreed upon by the City's representative.

6.3.2.3.5.3 Accident data. Traffic accident data should be obtained for the most current three-year period available.

6.3.2.3.5.4 Roadway and intersection geometrics. Roadway geometric information should be obtained. This includes, but is not limited to, roadway width, number of lanes, turning lanes, vertical grade, and location of nearby driveways, pedestrian facilities, and lane configuration at intersections.

6.3.2.3.5.5 Traffic control devices. The location and type of traffic controls should be identified.

6.3.2.3.5.6 Bicycle and pedestrian volumes. When directed by the City of Tucson's Traffic Engineer, bicycle and pedestrian volumes should be collected.

6.3.2.3.6 TRAFFIC VOLUME FORECASTS. Future traffic volumes should be estimated using information from transportation models, or applying an annual growth rate to the base-line traffic volumes. The future traffic volumes should be representative of the horizon year for project development. If the annual growth rate method is used, the City's representative must give prior approval to the growth rate.

In addition, any nearby proposed "on-line" development projects should be taken into consideration when forecasting future traffic volumes. The increase in traffic from proposed "on-line" projects should be compared to the increase in traffic by applying an annual growth rate. This information should be provided by the City's representative.

If modeling information is unavailable, the greatest traffic increase from either the "on-line" developments, the application of an annual growth

rate, or a combination of an annual growth rate and "on-line" developments, should be used to forecast the future traffic volumes.

6.3.2.3.7 TRIP GENERATION. The latest edition of *Institute of Transportation Engineers (ITE) Trip Generation Handbook* should be used for selecting trip generation rates. Other rates may be used with the approval of the City's representative in cases where the *ITE Trip Generation Handbook* does not include trip rates for a specific land use category, or includes only limited data, or where local trip rates have been shown to differ from the ITE rates.

Site traffic should be generated for daily, AM and PM peak hour periods. Adjustments made for "passer-by" and "mixed-use" traffic volumes should follow the methodology outlined in the latest edition of the *ITE Trip Generation Handbook*. A "passer-by" traffic volume discount for commercial centers should not exceed twenty five percent unless approved by the City's representative.

A trip generation table should be prepared showing proposed land use, trip rates, and vehicle trips for daily and peak hour periods and appropriate traffic volume adjustments, if applicable.

6.3.2.3.8 TRIP DISTRIBUTION AND ASSIGNMENT. Projected trips should be distributed and added to the projected non-site traffic on the roadways and intersections under study. The specific assumptions and data sources used in deriving trip distribution and assignment should be documented in the report and approved by the City's representative.

Category III TIA's may require the use of a travel demand model based on direction from the City's representative.

The site-generated traffic should be assigned to the street network in the study area based on the approved trip distribution percentages. The site traffic should be combined with the forecasted traffic volumes to show the total traffic conditions estimated at development completion. A "figure" will be required showing daily and peak period turning movement volumes for each traffic study intersection. In addition, a "figure" should be prepared showing the base-line volumes with site-generated traffic added to the street network. This "figure" will represent site specific traffic impacts to existing conditions.

6.3.2.3.9 CAPACITY ANALYSIS. Level of service (LOS) should be computed for signalized and unsignalized intersections in accordance with the latest edition of the Highway Capacity Manual. The intersection

LOS should be calculated for each of the following conditions (if applicable):

- 1) Existing peak hour traffic volumes ("figure" required).
- 2) Existing peak hour traffic volumes including site-generated traffic ("figure" required).
- 3) Future traffic volumes not including site traffic ("figure" required).
- 4) Future traffic volumes including site traffic ("figure" required).
- 5) LOS results for each traffic volume scenario ("table" required).

The LOS table should include LOS results for AM and PM peak periods if applicable. The table should show LOS conditions with corresponding vehicle delays for signalized intersections, and LOS conditions for the critical movements at unsignalized intersections. For signalized intersections, the LOS conditions and average vehicle delay should be provided for each approach and the intersection as a whole.

Unless otherwise directed by the City's representative, the capacity analysis for existing signalized intersections should be conducted using the Highway Capacity Manual Operational Method for each study horizon year. When directed by the City's representative, the capacity analysis should be conducted using the Planning Analysis Method.

When the operational capacity analysis method is used for existing signalized intersections, it should include existing phasing, timing, splits, and cycle lengths during the peak hour periods when available from the City's representative.

For unsignalized intersections, the Highway Capacity Manual methodology should be used.

If the new development is scheduled to be completed in phases, the TIA will, if directed by the City's representative, include a LOS analysis for each separate development phase in addition to the TIA for each horizon year. The incremental increases in site traffic from each phase should be included in the LOS analysis for each preceding year of development completion. A "figure" will be required for each horizon year of phased development.

6.3.2.3.10 QUEUE ANALYSIS. If directed by the City's representative, a queue analysis should be completed using the following methods outlined in Section 5.3.2.1 to determine appropriate storage lengths for right turn and left turn lanes into and out of the site.

6.3.2.3.11 TRAFFIC SIGNAL WARRANT ANALYSIS. A traffic signal warrant study should be conducted if directed by the City's representative. The analysis will be required for each horizon year.

Traffic signal warrant studies should be conducted by a method pre-approved by the City's representative.

6.3.2.3.12 ACCIDENT ANALYSIS. If directed by the City's representative, an analysis of three-year accident data should be conducted to determine the level of safety of the study area and any possible mitigation efforts.

6.3.2.3.13 SPEED ANALYSIS. Vehicle speed is used to estimate safe stopping and cross corner sight distances. In general, the posted speed limit is representative of the 85th percentile speed and may be used to calculate safe stopping and cross corner sight distances. If directed by the City's representative, speed counts should be taken in the study area.

6.3.2.3.14 TRAFFIC SIMULATION. For a major development, a simulation using SYNCHRO or other approved software should be done to show existing traffic flows and future traffic flows if directed by the City's representative.

6.3.2.3.15 MITIGATION REQUIREMENTS. The roadways and intersections within the study area should be analyzed, with and without the proposed development to identify any projected impacts in regard to level of service and safety.

Where the roadway will not operate at Level of Service D or better with the development, the traffic impact of the development on the roadways and intersections within the study area shall be mitigated to Level of Service D.

6.3.2.3.16 INTER-AGENCY COORDINATION. When a new development falls within the boundaries of more than one government agency jurisdiction, the TIA should be distributed as an informational report to all affected agencies. The agency with governing powers over the development site will have final approval of the TIA.

6.3.2.4 Report Format. This sub-section provides the format requirements for the general text arrangement of a TIA. Deviations from this format must receive prior approval of the City's representative.

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Conclusions

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Land Use and Intensity
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Access Geometrics
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Locations
Types - Daily, Morning, and Afternoon Peak Periods
(two hours minimum, and others as required)

6.3.2.4.8 TRIP GENERATION

Trip Generation
Pass-by Traffic (if applicable)

6.3.2.4.9 TRIP DISTRIBUTION AND ASSIGNMENT

Trip Distribution
Trip Assignment

6.3.2.4.10 ACCESS

Site Access
Driveways

6.3.2.4.11 ACCIDENT ANALYSIS

Analysis Years
Types of Accidents
DUI
Injury
Non-injury
Fatalities

6.3.2.4.12 EXISTING TRAFFIC OPERATIONS

Level of Service
Morning Peak Hour, Afternoon Peak Hour
(and others as required)

6.3.2.4.13 FUTURE TRAFFIC OPERATIONS WITHOUT PROJECT

Projections of non-site traffic (Methodology for projections should receive prior approval of City's representative)
Roadway Improvements
Improvements Programmed to Accommodate Non-site Traffic
Additional Alternative Improvements to Accommodate Site Traffic
Level of Service Analysis Without Project (for each horizon year including any programmed improvements)

6.3.2.4.14 TRAFFIC SIGNAL WARRANT ANALYSIS

Warrant Analysis should be performed for each horizon year with and without project (Methodology for analysis should receive prior approval of City's representative)

6.3.2.4.15 FUTURE TRAFFIC OPERATIONS WITH PROJECT

Level of Service Analysis With Project (for each horizon year, including any programmed improvements)

6.3.2.4.16 SUGGESTED TRAFFIC MITIGATIONS

Pedestrian/Bicycle Considerations
Traffic Control Needs
Intersection Channelization Mitigation
Neighborhood Traffic Mitigation

6.3.2.4.17 TURN LANE ANALYSIS

Turn lane need
Turn lane storage lengths

6.3.2.4.18 CONCLUSION

Trips Generated
Trip Impacts
 Vehicular
 Pedestrian
 Bicycle
 Transit
Recommendations
Other

6.3.2.4.19 APPENDICIES

Traffic Volume Counts
Capacity Analyses Worksheets
Traffic Signal Warrant Analysis
Accident Data and Summaries
Miscellaneous Addendum

6.4 Existing Problem Areas

Introducing a “retrofit” program of access control to an existing roadway is often difficult. Land for needed improvements is often unavailable, making certain access management techniques impossible to implement and requiring the use of minimum rather than desirable standards. Rights of property access should be respected. Social and political pressures will emerge from abutting property owners who perceive that their access will be unduly restricted and their business hurt. The needed cooperation of proximate, sometimes competitive, developments in rationalizing on-site access and driveway locations may be difficult to achieve. And it may also be difficult to compare the cost of economic hardship to an individual to the benefits accruing to the general public. Accordingly, the legal, social, and political aspects of access management are particularly relevant in retrofit situations and

should be thoroughly understood by public agencies and private groups responsible for implementing access control programs for retrofit projects.

The general reasons underlying retrofit actions include the following:

- 1) Increased congestion and accidents along a given section of road that are attributed to random or inadequate access;
- 2) Major construction or design plans for a road that make access management and control essential;
- 3) Street expansions or improvements that make it practical to reorient access to a cross street and remove (or reduce) arterial access; and
- 4) Coordinating driveways, on one side of a street, with those planned by a development on the other side.

6.4.1 Types of Action. Most retrofit actions involve the application of accepted traffic engineering techniques that limit the number of conflict points, separate basic conflict areas, limit speed adjustment problems, and remove turning vehicles from the through travel lanes. Tables 6-1 through 6-4 presents the various access management techniques that achieve each of these objectives and mainly apply to retrofit situations.

TABLE 6-1¹
Retrofit Techniques – Category A

CATEGORY A – Limit Number of Conflict Points	
No.	Description
A-1	Install median barrier with no direct left-turn access
A-2	Install raised median divider with left-turn deceleration lanes
A-3	Install one-way operations on the roadway
A-4	Install traffic signal at high-volume driveways
A-5	Channelize median openings to prevent left-turn ingress and/or egress maneuvers
A-6	Widen right through lane to limit right-turn encroachment onto the adjacent lane to the left
A-7	Install channelizing islands to prevent left-turn deceleration lane vehicles from returning to the through lanes
A-8	Install physical barrier to prevent uncontrolled access along property frontages
A-9	Install median channelization to control the merge of left-turn egress vehicles
A-10	Offset opposing driveways
A-11	Locate driveway opposite a three-leg intersection or driveway and install traffic signals where warranted
A-12	Install two one-way driveways in lieu of one two-way driveway
A-13	Install two two-way driveways with limited turns in lieu of one standard two-way driveway
A-14	Install two one-way driveways in lieu of two two-way driveways
A-15	Install two two-way driveways with limited turns in lieu of two standard two-way driveways
A-16	Install driveway channelizing island to prevent left-turn maneuvers
A-17	Install driveway channelizing island to prevent driveway encroachment conflicts
A-18	Install channelizing island to prevent right-turn deceleration lane vehicles from returning to the through lanes
A-19	Install channelizing island to control the merge area of right-turn egress vehicles
A-20	Regulate the maximum width of driveways

¹ Adapted from: Federal Highway Administration. (1998)

TABLE 6-2¹
Retrofit Techniques – Category B

CATEGORY B – Separate Basic Conflict Areas	
No.	Description
B-1*	Regulate minimum spacing of driveways
B-2	Regulate minimum corner clearance
B-3	Regulate minimum property clearance
B-4*	Optimize driveway spacing in the permit authorization stage
B-5*	Regulate maximum number of driveways per property frontage
B-6	Consolidate access for adjacent properties
B-7	Require roadway damages for extra driveways
B-8	Purchase abutting properties
B-9	Deny access to small frontage
B-10	Consolidate existing access whenever separate parcels are assembled under one purpose, plan, entity, or usage
B-11*	Designate the number of driveways regardless of future subdivision of that property
B-12	Require access on collector street (when available) in lieu of additional driveway on arterial

* = not directly applicable for retrofit

TABLE 6-3¹
Retrofit Techniques – Category C

CATEGORY C – Limit Speed-Adjustment Problems	
No.	Description
C-1	Install traffic signals to slow roadway speeds and meter traffic for larger gaps
C-2	Restrict parking on the roadway next to driveways to increase driveway turning speeds
C-3	Install visual cues of the driveway
C-4	Improve driveway sight distance
C-5	Regulate minimum sight distance
C-6*	Optimize sight distance in the permit authorization stage
C-7	Increase the effective approach width of the driveway (horizontal geometrics)
C-8	Improve the driveway profile (vertical geometrics)
C-9	Require driveway paving
C-10	Regulate driveway construction (performance bond) and maintenance
C-11	Install right-turn acceleration lane
C-12	Install channelizing islands to prevent driveway vehicles from backing onto the arterial
C-13	Install channelizing islands to move ingress merge point laterally away from the arterial
C-14	Move sidewalk-driveway crossing laterally away from the arterial.

* = not directly applicable for retrofit

¹ Adapted from: Federal Highway Administration. (1998)

TABLE 6-4¹
Retrofit Techniques – Category D

CATEGORY D – Remove Turning Vehicles from the Through Lanes	
No.	Description
D-1	Install two-way left-turn lane
D-2	Install continuous left-turn lane
D-3	Install alternating left-turn lane
D-4	Install isolated median and deceleration lane to shadow and store left-turning vehicles
D-5	Install left-turn deceleration lane in lieu of right-angle crossover
D-6	Install median storage for left-turn egress vehicles
D-7	Increase storage capacity of existing left-turn deceleration lane
D-8	Increase the turning speed of right-angle median crossovers by increasing the effective approach width
D-9	Install continuous right-turn lane
D-10	Construct a local service road
D-11*	Construct a bypass road
D-12*	Reroute through traffic
D-13	Install supplementary one-way right-turn driveways to divided roadway (non-capacity warrant)
D-14	Install supplementary access on collector street when available (non-capacity warrant)
D-15	Install additional driveway when total driveway demand exceeds capacity
D-16	Install right-turn deceleration lane
D-17	Install additional exit lane on driveway
D-18	Encourage connections between adjacent properties (even when each has arterial access)
D-19	Require two-way driveway operation where internal circulation is not available
D-20	Require adequate internal design and circulation plan

* = not directly applicable for retrofit

¹ Adapted from: Federal Highway Administration. (1998)

7.0 Guideline References (Effective January 2003)

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